OmniaScience

Journal of Technology and Science Education
JOTSE, 2016 – 6(3): 219-233 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349
http://dx.doi.org/10.3926/jotse.227

DESIGN AND VALIDATION OF A QUESTIONNAIRE TO MEASURE RESEARCH SKILLS: EXPERIENCE WITH ENGINEERING STUDENTS

Fabián Cobos Alvarado[1], Mónica Peñaherrera León[2], Ana María Ortiz Colon[3]

[1]University of Armed Forces (Ecuador)

[2]Council of Evaluation, Accreditation and Quality Assurance of Higher Education (Ecuador)

[3]University of Jaen (Spain)

efabianco@gmail.com, mpenaherrera@ceaaces.gob.ec, aortiz@ujaen.es

Received May 2016

Accepted September 2016

Abstract

Universities in Latin American countries are undergoing major changes in its institutional and academic settings. One strategy for continuous improvement of teaching and learning process is the incorporation of methods and teaching aids seeking to develop scientific research skills in students from their undergraduate studies.

The aim of this study is the validation of a questionnaire to measure research skills with engineering students.

Questionnaire validation was performed by: literature review, semantic and content validation by experts from three Latin American universities, finishing with a factorial and reliability validation. The instrument was applied to 150 students (75.3% men and 24.7% women) that were enrolled in the basic level of engineering.

The validated questionnaire has 20 items. The correlations between factors of the instrument, show relationship and dependence between them, indicating the validity of the questionnaire. The reliability of the instrument was calculated using Cronbach's alpha coefficient, which reached a value of .91 in the total scale.

The statistical results to validate the questionnaire have been significant, allowing us to propose this experience as a starting point to implement further studies about the development of research skills in university's students from other areas of knowledge.

Keywords – Validation, Learning, Research skills, University.

1. Introduction

We may translate the challenges of higher education into the necessity of training students that could be more competitive in accordance of the actual knowledge society in which we live; this will require developing and entrenching strong thinking skills, intellectual flexibility, creativity, analysis and the capability to replicate and create knowledge.

Some authors such as Hurtado (2000), Lipman (2001), Restrepo (2003), Tünnermann (2003), Sayous (2007), García and Ladino (2008) and Brew (2013) agree on the need to train students to develop research skills from their undergraduate studies.

Research as a learning process, has been conceived as the result of a process and strategy that could have started to developed in the first academic year of the students, and not as the culmination of their training. Hence, the fact that students from the postgraduate research begin their training in investigation at that moment and not from the undergraduate makes students see the researching process more like a requirement to complete their studies than a pillar of their education.

Hunter, Laursen and Seymour (2007) conducted a study in four liberal arts universities, addressing fundamental questions about the benefits of participation in undergraduate research projects. The results were highly positive, the students who participated in the investigation have been "thinking and working" as a scientist (23%), wanted to become a scientist (20%) believe they have gained some benefits personal-professional (19%), have been cleared / confirmed career plans (16%), improved career (10%), improving skills like arguing and presenting information, organize projects and work, understanding and written expression (8%). the most important found in the study is that students want to "become scientists," manifested themselves and supported by half of the observations of teachers (52%), the latter described the changes observed in the behavior and the way students began to exhibit behaviors and attitudes that are a researcher, as curiosity and initiative, were becoming less fearful of taking responsibility for research and more willing to take risks, trust the ability to research, interest in contributing to science, presentation of research and defend them, among others.

Likewise, Ward, Bennett and Bauer (2003) conducted a study to evaluate the educational effectiveness of research experience in undergraduates; students indicated that by getting involved in research projects facilitated their learning.

On the other hand, the knowledge society warns that research is a fundamental function of every university (González, Galindo, Galindo & Gold, 2004; Cerda-Gutiérrez, 2006) and should be, therefore should be linked not only teachers but also the learning processes of students (Nuñez, 2007).

The report of the Boyer Commission for Education Research Universities in the United States, recommended the implementation the method research-based learning (RBL), because higher education offering American universities lacked adequate scientific literacy, and a low commitment to the creation and production of knowledge and had separation of research and teaching activities in university classrooms (The Boyer Commission, 1998).

The Council of Undergraduate Research of the United States notes that undergraduate research is unquestionable and should be seen as "an investigation conducted by a college student who makes an original intellectual or creative contribution to the discipline (Council for Undergraduate Research, 2013).

The European Union has recognized learning by guided research (Inquiry Based Learning) as the ideal methodology to improve the teaching of science and mathematics (European Commission, 2008; European Commission, 2011; National Research Council, 2000, cited by Abril, Ariza, Quesada & García, 2013).

There are other experiences on incorporating research and teaching-learning strategy at grade level. Thus, -University of Warwick in the UK, The University of Adelaide in Australia and South Carolina Honors College of the United States are examples of institutions that have adopted the research-based learning focus on learning processes of different degrees, the first, developed the model in different undergraduate degrees; the second, has developed a conceptual framework based on research in the curriculum of the different degrees; and the third, has been used as a strategy type curriculum that allows its graduates to be more competitive for scholarships and admission to professional schools (Martínez & Buendía, 2005).

Healey and Jenkins (2009), with reference to Griffiths (2004) have developed a framework to help conceptualize and explain how research is integrated into the learning environment undergraduate students, depending on whether the learning opportunity is focused student-centered or teacher, or if the learning opportunity focuses on product research or the research process itself. The framework identifies four ways of how research can be introduced into teaching:

- Teaching guided by research: the curriculum is dominated by the interests of the institution.
- Teaching oriented research: the student learns about the research process, how knowledge is created, and the researcher's mind.
- Based-research learning: Students act as researchers, learn associated skills, the curriculum is dominated by search-based activities. Teaching is aimed at helping students understand the phenomena of how the experts do it.
- Inquiry Based Learning connects student learning in the context of a problem.

In the Latin American context, the Monterrey Institute of Technology and Higher Education, defined based research and application of teaching strategies and learning that are intended to connect research with teaching and learning, which allow partial or total incorporation of the student in a research based in scientific methods, under the supervision of professor (Instituto Tecnológico de Estudios Superiores de Monterrey, 2010).

For Chávez (2013), Rojas and Méndez (2013), Morales, Rincón and Romero (2004), there are some additional advantages by using research-based learning, in particular would be:

- Enter the student in the way of research and empowers teachers working in it.
- Establishes a link between academic programs and potential areas of research institution and research groups.
- Promotes students during their years of study are able to develop the skills necessary to investigate (critical thinking, analysis, synthesis, leadership, creativity, entrepreneurship, problem solving, etc.) in order to involve them in the process of scientific discovery skills within classroom work in their specific scientific disciplines.
- Students learn in the context of research seeking new knowledge and acquire commitments to lifelong learning.
- The teacher has the ability to target the entire research process more efficiently, to the extent that successful experiences can be extrapolated in the classroom.

For other authors, the advantages of using the research-based learning approach is determined by the development of skills, and these are defined as those intellectual capacities that are associated with performing certain actions you can run the business subject and which mostly develop only when you access own research tasks (Moreno, 2002).

The research-based learning is conceived as one of the strategies best suited to develop culture and research skills, it proposes that learning is built on real scenarios that link students and teachers in a building process knowledge inspired by the process of scientific research.

Identifying research skills could guide teachers and researchers to include research as learning method. The shortage of these instruments led to the creation of the scale of "Self-rated skills for research-based learning" (AHABI). The aim of this study is to develop an instrument to measure research skills and serve as reference to include the teaching research focus on the learning process of students.

2. Methodology

Research has implemented a quasi-experimental design with control and experimental group. The experimental group was exposed to the influence of RBL method and the control group remained free from the influence. These groups have not been matched by randomization and hence are not equivalent groups; they had been already formed. Therefore the design that has been raised is adjusted to the conditions in educational research (Arnal, Del Rincon and Latorre, 1992).

2.1. Participants

The study sample was composed by 150 students (75.3% men and 24.7% women) aged between 16 and 27 years, divided into four groups, which belonged to the class of Physics, Differential Calculus, General Chemistry I, General Chemistry. The sample was probabilistic and intentional and constitutes of students groups of basic cycle engineering.

2.2. Instruments

Validated measurement instrument "AHABI" is a self-rated questionnaire consisting of 20 items, according to a Likert scale (1 means strongly disagree and 5 strongly agree). The design and development of the Likert scale was developed in three phases.

In the first phase a literature review was conducted, of those elements that influence the development of research skills in students and instruments proposed to measure these skills. the lack of specific instruments to analyze variables related research skills, there are some general references were reviewed, among them are the "Scale attitude towards learning research" (ESCAI) of Ruiz and Torres (2002); the questionnaire for identifying general skills and qualities of scientific research of Fernández, Cordeiro, Cordeiro and Pérez (2004); Attitudes Toward scale research of Papanastasiou (2005); self-assessment tool research skills, Rivera and Torres (2006); and an inventory of skills for university research (ICUNI) Sierra, Alejo and Silva (2011).

In the second phase, to validate the contents of the questionnaire, were selected 8 experts from two universities of Spain and one university of Ecuador, with experience in the field of educational research, which would urge them to give their professional judgment about semantics and content of the scale addition, evaluation of the structure of the questionnaire, understanding of the items, analysis of the format and presentation of the questionnaire, and to the analysis of the following questions What other aspects should pick up the scale? What items should be deleted? In this process valuation experts recommended the removal 20 items falling in 36 of the 56 items initially plated on the scale.

In the third phase we proceeded to the factorial validation of the instrument, the scale was subjected to analysis of reliability and validity, with a sample of 150 students who were not part of the course for the development of research skills, but had characteristics similar to experimental and control group, with this action, the basic assumption that if you are going to make a factorial analysis, the sample should not lose 150 subjects (Morales, Urosa & Blanco, 2003). The main objective is to check whether the 36 items of the scale can be summarized in some way, if there are commonalities between them.

For the realization of this study is were analyzed three factors: the first is "Process scientific information," the second "Managing scientific information" and the third is "Develop scientific information", for the analysis and contextualization of these factors have taken into account other data to define the sample such as the type and year career coursing, age, sex.

2.3. Process

It fulfilled the reporting procedures, compliance and acceptance of student participation in this study; we proceeded to the administration of the questionnaires, whose characteristics confidentiality and voluntariness in their filling. Self-administered questionnaire spent during regular classes, requesting authorization of the corresponding teacher, in the case of the control groups. For the experimental groups, the questionnaire was administered before and after training sessions on developing research skills. In both cases, the researcher was present, which gave precise instructions for students to complete the questionnaire; students took approximately 20 minutes to respond the instrument.

2.4. Statistical analysis

Data from this study were obtained using the SPSS statistical program for Windows V.20.0. They were calculated analysis of internal reliability (Cronbach's alpha) of the questionnaire. The Varimax orthogonal rotation method helped us to group reagents or components factors that may explain the observed variance in the answers given by the subjects (Escalante & Caro, 2006). Next, we analyze the correlation between variables, which must be high in order to perform the factorial analysis. The index KMO (Kaiser, 1970) sampling adequacy and Bartlett sphericity (Bartlett, 1950) test was also used.

2.5. Factorial validity

Once verified that the sample size was the ideal number of subjects for the study, we proceeded to study the factorial validity of the instrument scale to see if the 36 items of the scale can be summarized, is grouping them say whether there are commonalities between them. The homogeneity of the questionnaire was calculated, allowing us to remove 16 items that had a low level of discrimination and therefore a correlation <200 with the total scale, according to the recommendations of Elbel (1965). The scale was composed of 20 items with Cronbach's alpha reliability of .91.

Then the degree of correlation between the variables was studied, the values of this analysis should be high in order to perform the factorial analysis. The KMO sampling adequacy ratio reached the value of .891 and Barlett sphericity test reaches 1429.971 ($p < .001$). These data deemed that the answers are substantially related, justifying the realization of factor analysis.

Then we determine commonalities or proportion of variance that is explained by the common factors, which resulted in three common factors. In general, the absence of values close to zero, it can be stated that the 20 items are explained by the components. The analysis of main components and Varimax rotation revealed, after eleven iterations, the convergence of three factors which explain 54.848% of the variance. The first component is the most amount of variance explained with 24.708%, the second factor with 16.436% and the third with a 13.705%, as shown in Table 1.

	Factor 1	**Factor 2**	**Factor 3**
% Variance	24.708	16.436	13.705
% accumulated	24.708	41.143	54.848

Table 1. Variance explained according factors

The analysis, the items were ordered according to the degree of saturation presenting a higher load factor 3 (Table 2).

Items	**Factor 1**	**Factor 2**	**Factor 3**
1. I management research articles of a theme drawn from scientific journals, databases, etc.		.510	
2. I recognize a scientific paper in a document of Wikipedia, Rincón del Vago, etc.		.408	
3. I know what is literature review		.589	
4. I identify scientific journals		.628	
5. I recognize database of scientific journals		.812	
6. I identify the structure of a scientific research article		.569	
7. I use scientific techniques to organize information	.563		
8. I analyze main ideas of a scientific article	.648		
9. I reflect as I read a scientific article	.598		
10. I interpret data, graphics, etc. a scientific article	.636		
11. I summarize scientific information	.664		
12. Discuss critically research article	.544		
13. I make conclusions after reviewing scientific literature	.632		
14. I prepare an abstract / essay of a research topic			.942
15. I use references according to rules of scientific writing in a text that I elaborate, is an abstract or essay			.490
16. I write in English keywords for a research topic			.297
17. I identify a new research topic in the literature review	.450		
18. I am able to communicate orally the results of a review of scientific literature		.629	
19. I Elaborate keywords of a research topic			.376
20 I bring my ideas in developing a research topic			.347
Cronbach's alpha coefficients	.891	.711	.687

Table 2. Matrix rotated component and Cronbach´s Alpha by factor

The correlations of factors indicate relationship and dependence between them, can say that the data confirm the validity of the questionnaire, with a structure of three factors.

The first factor group items 7, 8, 9, 10, 11, 12, 13 and 17, these items assess skills related to the organization of collecting scientific information. This factor is given the name "Process scientific information".

The second corresponds to items 1, 2, 3, 4, 5, 6 and 18. These items assess skills regarding the management and search of scientific information. This factor is called "Managing scientific information".

The third factor is part of the group of items 14, 15, 16, 19 and 20; these items assess implementation related to new understandings and new working skills. The name of the factor is "Develop scientific information".

2.6. Reliability Analysis

Once the validity of the scale established, the reliability of the instrument was calculated by Cronbach's alpha coefficient, which reaches a value of .91 in the total scale; .891 for the factor 1 "Process scientific information"; .711 for the factor 2 "Managing scientific information"; and . 687 for the factor 3 "Develop scientific information", indicating adequate internal consistency of the instrument, which makes the AHABI reliable instrument. The following table 3 shows the reliability of the scale by the item-total correlation, which reflects the means between the groups with higher and lower total scores, in our analysis we have values ranging between .89 and .92, a small strip which ensures basic instrument dimensionality.

	Average scale if the item is deleted	Scale variance if the item is deleted	Total corrected correlation-element	Cronbach's alpha if the item is removed
Item 1	79.31	293.75	0.59	.89
Item 2	78.53	307.82	0.43	.90
Item 3	78.87	318.07	0.24	.91
Item 4	78.65	301.11	0.60	.90
Item 5	79.45	292.45	0.72	.89
Item 6	79.25	302.86	0.54	.90
Item 7	79.81	306.67	0.38	.91
Item 8	79.30	310.43	0.32	.91
Item 9	80.07	295.33	0.58	.90
Iem 10	79.92	302.30	0.57	.90
Item 11	80.69	349.07	-0.32	.92
Item 12	80.48	316.48	0.36	.91
Item 13	80.66	321.54	0.27	.91
Item 14	80.09	322.20	0.23	.91
Item 15	80.28	310.11	0.42	.90
Item 16	79.06	305.22	0.51	.90
Item 17	79.16	296.94	0.65	.89
Item 18	80.96	310.61	0.46	.90
Item 19	80.70	315.81	0.36	.91
Item 20	79.31	316.92	0.33	.91

Table 3. Correlation items with total scale

3. Discussion

Significant results of this research are consistent with those found in the literature survey of other studies that have pointed to the effectiveness of a system based on skills development research method, proving to be a learning strategy for students cognitively attractive undergraduate many disciplines, and allowing them to work increasingly academic logic and research. (Hunter et al., 2007; Ward et al., 2003; Willison and O'Regan, 2007; Chaplin, 2003; Hoskins, Stevens & Nehm, 2007; Luckie, Maleszewski, Loznak & Krha, 2004). In the same way in line with the conclusions drawn by Willison (2009) and reflected in its proposed of Research Skill Development and its application in some undergraduate programs (tourism, Engineering, Health, etc.) at the University of Adelaide, choosing different types and facets of research for each area (research Literature Review, field, laboratory).

The factors that form the questionnaire, "Process scientific information", "Managing scientific information" and "Develop scientific information" could evaluate proposals like Bastidas (2013), who mentions that based teaching research students act as researchers learn related skills and teaching aims to help students understand the phenomena of how the experts do it, plus it could assess the methodological proposals of Rizo (2012) and Torres (2012).

4. Conclusions

The scale has high internal consistency since the Cronbach alpha coefficient reached the .91. Additional saturations of each item with their respective factors have high values. On the other hand, correlations between factors indicate a good relationship and dependence between them, so we can say that this study has generated a valid measure learning research skills instrument, since the results presented, as a whole, confirm the high reliability, also factorial validity and content.

Factors 1, 2 and 3 grouped questionnaire items, indicating adequate internal consistency, so the AHABI is deemed reliable instrument for use in program evaluation with a focus on teaching research at the university.

Having reached the goal of the research, it contributes to this study to new learning experiences in university classrooms that allow time to develop and evaluate innovative forms of education is incorporated, The method of teaching research not only provides micro curriculum level, but also at the policy level for the quality of higher education.

References

Abril, A., Ariza, M., Quesada, A., & García, J. (2013). Creencias del profesorado en ejercicio y en formación sobre el aprendizaje por investigación. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, 11(1), 22-33.

Arnal, J., del Rincón, D., & Latorre, A. (1992). *Investigación educativa. Metodologías de investigación educativa*. Barcelona: Labor.

Bartlett, M.S. (1950). *Test of significance in factor analysis*. England: University of Manchester.

Bastidas, V. (2013). *Aprendizaje Basado en Investigación*. Retrieved from: http://sitios.itesm.mx/va/dide2/tecnicas_didacticas/abi/abi.htm

Boyer Commission Report (1998). *The Boyer Commission on Educating Undergraduates in the Research University, Reinventing Undergraduate Education: A Blueprint for America's Research Universities*. Retrieved from: http://www.niu.edu/engagedlearning/research/pdfs/Boyer_Report.pdf

Brew, A. (2013). Understanding the scope of undergraduate research: A framework for curricular and pedagogical decision-making. *Higher Education*, (66), 603-618. http://dx.doi.org/10.1007/s10734-013-9624-x

Cerda-Gutiérrez, H. (2006). *Formación investigativa en la Educación Superior Colombiana*. Universidad Cooperativa de Colombia. Bogotá: EDUCC.

Chávez, G. (2013). *La investigación formativa en la universidad. Proyecto de investigación del Cuerpo Académico "Cambio educativo: discursos, actores y prácticas"*. México: Universidad Autónoma de Nuevo León.

Chaplin, S. (2003). *Guided development of independent inquiry in an anatomy/physiology laboratory. Advances in Physiology Education*. Minnesota: University of St. Thomas.

Council for Undergraduate Research (2013). *About CUR: Frequent questions*. Retrieved from: http://www.cur.org/about_cur/frequently_asked_questions_/#2

Elbel, R. (1965). *Measuring educational achievement*. Englewood: Prentice-Hall.

Escalante, E., & Caro, A. (2006). *Investigación y análisis estadísticos de datos en SPSS*. Mendoza: FEEyE.

Fernández, D., Cordeiro, A., Cordeiro, E., & Pérez, C. (2004). Diseño de un cuestionario para la identificación de las habilidades generales y las cualidades del investigador científico. *Pedagogía Universitaria*, 9(1), 25-36.

García, G.A., & Ladino, Y. (2008). Desarrollo de competencias científicas a través de una estrategia de enseñanza y aprendizaje por investigación. *Studiositas*, 3(3), 7-16.

González, J., Galindo, N., Galindo, J.L., & Gold, M. (2004). *Los paradigmas de la calidad educativa. De la autoevaluación a la acreditación*. México: Unión de Universidades de América Latina.

Griffiths, R. (2004). Knowledge production and the research-learning nexus: The case of the built environment disciplines. *Studies in Higher Education*, 29(6), 709-726. http://dx.doi.org/10.1080/0307507042000287212

Healey M., & Jenkins, A. (2009). *Undergraduate Research and Inquiry*. York: Higher Education Academy.

Hoskins, S. Stevens, L., & Nehm, R. (2007). Selective Use of the primary literature transforms the classroom into a virtual laboratory. *Genetics*, 176, 1381-1389. http://dx.doi.org/10.1534/genetics.107.071183

Hunter, A., Laursen, S., & Seymour, E. (2007). Becoming a Scientist: the role of undergraduate research in students' cognitive, personal and professional development. *Science Education*, 91, 36-74. http://dx.doi.org/10.1002/sce.20173

Hurtado, J. (2000). *Retos y alternativas en la formación de investigadores*. Venezuela: SYPAL.

Instituto Tecnológico de Estudios Superiores de Monterrey (2010). *Aprendizaje basado en investigación. Investigación e Innovación Educativa*. Retrieved from: http://sitios.itesm.mx/va/dide2/tecnicas_didacticas/abi/copabi.htm

Kaiser, H.F. (1970). A second generation Little Jiffy. *Psycometrika*, 35, 401-415. http://dx.doi.org/10.1007/BF02291817

Lipman, M. (2001). *Pensamiento Complejo y Educación*. Madrid: Ediciones de la Torre.

Luckie, D., Maleszewski, J., Loznak, S., & Krha, M. (2004). Infusion of collaborative inquiry throughout a biology curriculum increases student learning: a four year study of "Teams and Streams". *Advances in Physiology Education*, 28, 199-209. http://dx.doi.org/10.1152/advan.00025.2004

Martínez, A., & Buendía, A. (2005). *Aprendizaje basado en la investigación. Tecnológico de Monterrey*. Retrieved from: http://www.mty.itesm.mx/rectoria/dda/rieee/pdf-05/29(EGADE).A.BuendiaA.Mtz.pdf

Morales, P., Urosa, B., & Blanco, A. (2003). *Construcción de escalas de actitudes tipo Likert*. Madrid: La Muralla.

Morales, O. Rincón, A., & Romero, J. (2004). Cómo enseñar a investigar en la universidad. *Educere*, 9(29), 217-224.

Moreno, M. (2002). *Formación para la investigación centrada en el desarrollo de habilidades*. México: Universidad de Guadalajara.

Núñez, N. (2007). Desarrollo de habilidades para la investigación (DHIN). *Revista Iberoamericana de Educación*, 44, 6-15.

Papanastasiou, E. (2005). Factor structure of the attitudes toward research scale. *Statistics Education Research Journal*, 4(1), 16-26.

Restrepo, B. (2003). Investigación formativa e investigación productiva de conocimiento en la universidad. *Nómadas*, 18, 195-202.

Rivera, Mª E., & Torres, C. (2006). Percepción de los estudiantes universitarios de sus propias habilidades de investigación. *Revista de la Comisión de Investigación de FIMPES*, 1(1), 36-49.

Rizo, M (2012). *Enseñar a investigar investigando. Experiencias de investigación en comunicación con estudiantes de la Licenciatura en Comunicación y Cultura de la Universidad Autónoma de la Ciudad de México*. México: Universidad Autónoma de la Ciudad de México.

Rojas, M., & Méndez, R. (2013). Cómo enseñar a investigar. Un reto para la pedagogía universitaria. *Educ.*, 1(16), 95-108.

Ruiz, C., & Torres, V. (2002). Actitud hacia el aprendizaje de la investigación. Conceptualización y medición. *Educación y Ciencias Humanas*, X (18), 15-30.

Sayous, N. (2007). La investigación científica y el aprendizaje social para la producción de conocimientos en la formación del ingeniero civil. *Ingeniería*, 11(2), 39-46.

Sierra, M., Alejo, M., & Silva, F. (2011). *Evaluación de competencias de investigación en alumnos de licenciatura en psicología*. Retrieved from: http://www.researchgate.net/publication/232069603_Evaluacin_de_competencias_de_investigacin_en_alumnos_de_licenciatura_en_Psicologa

Torres, A. (2012). *Aprendizaje Basado en la Investigación. Técnicas Didácticas. Tecnológico de Monterrey*. Retrieved from: http://rodin.uca.es:8081/xmlui/bitstream/handle/10498/15117/7313_Penaherrera.pdf?sequence=7

Tünnermann, C. (2003). *La universidad latinoamericana ante los retos del siglo XXI*. México: Universidad Autónoma de Yucatán Mérida.

Ward, C. Bennett, J., & Bauer, K.W. (2003). Content analysis of undergraduate research student evaluations. Retrieved from: https://www.sarc.miami.edu/ReinventionCenter/Public/assets/files/contentAnalysis.pdf

Willison, J. (2009). Multiple contexts, multiple outcomes, one conceptual framework for research skill development in the undergraduate curriculum. *Spring*, (29)3, 10-14.

Willison, J., & O'Regan. K. (2007). Commonly known, commonly not known, totally unknown: A framework for students becoming researchers. *Higher Education Research and Development*, 26(4), 393-405. http://dx.doi.org/10.1080/07294360701658609

Published by OmniaScience (www.omniascience.com)

Journal of Technology and Science Education, 2016 (www.jotse.org)